



Recovery Plan for

Helianthus eggertii

Eggert's Sunflower



U.S. Fish and Wildlife Service
Southeast Region
Atlanta, Georgia

RECOVERY PLAN

for

Helianthus eggertii (Eggert's Sunflower)

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Southeast Region
Atlanta, Georgia

Approved:


Regional Director, U.S. Fish and Wildlife Service

Date:

12-9-99

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By approving this recovery plan, the Regional Director certifies that the data used in its development represent the best scientific and commercial information available at the time it was written. Copies of all documents reviewed in the development of this plan are available in the administrative record located at the Asheville Field Office in Asheville, North Carolina.

Literature citations should read as follows:

U.S. Fish and Wildlife Service. 1999. Recovery Plan for *Helianthus eggertii* Small (Eggert's Sunflower). Atlanta, GA. 40 pp.

Additional copies may be purchased from:

Fish and Wildlife Reference Service
5430 Grosvenor Lane, Suite 110
Bethesda, Maryland 20814
Phone: 301/492-6403 or
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EXECUTIVE SUMMARY

Current Status: The U.S. Fish and Wildlife Service listed Eggert's sunflower (*Helianthus eggertii*) as a threatened species on May 22, 1997. This perennial (lives for several/many years) sunflower is found within the Highland Rim (mostly the western and eastern) and Shawnee Hills sections of the Interior Low Plateau Province, with one outlying occurrence on the Cumberland Plateau of Kentucky, Tennessee, and Alabama.

Habitat Requirements and Limiting Factors: *Helianthus eggertii* is a perennial that can form extensive clonal clumps (multiple plants descended from a single parent plant) through rhizomatous extensions (roots capable of producing new plants). Eggert's sunflower is typically found at the interface of woodlands and grassy openings within the barrens (a community with a mosaic of habitats ranging from open grasslands to oak woodlands to mixed forest) and, historically, was probably associated with tree stands across the barrens. Although open to semi-open barrens and woodlands appear optimal for *H. eggertii*, it also tolerates considerable disturbance and a range of light conditions and moisture levels. It persists in, and may even invade, roadsides, power line rights-of-way, or fields that have suitable open habitat. Eggert's sunflower is usually associated with concentrations of barren community types in Alabama, Kentucky, and Tennessee. Threats to this species are loss of habitat through conversion of the habitat for other uses, fire suppression, exotic plant invasion, and right-of-way (roadside and powerline) maintenance (herbicide spraying and inappropriately timed mowing).

Recovery Objective: Delisting.

Recovery Criteria: Eggert's sunflower (*Helianthus eggertii*) will be considered for delisting when:

1. Long-term conservation/protection of 20 geographically distinct self-sustaining populations (distributed throughout the species' range or as determined by genetic uniqueness) has been provided through management agreements or conservation easements on public land or land owned by private conservation groups.
2. These populations must be under a management regime designed to maintain or improve the habitat, and each population must be stable or increasing for 5 years.

Actions Needed:

1. Determine optimal habitat or range of optimal habitats and develop site-specific management strategies.
2. Develop management plans and conservation agreements for populations of Eggert's sunflower determined to be essential to the recovery of the species and for other populations as well, where there are willing landowners/managers.
3. Evaluate the ecological genetics of the species.

4. Determine whether introgression (the spread of genes from one species into the gene complex of another) with other species is occurring and evaluate introgression as a threat to the species.
5. Determine an estimate of the minimum viable population size.
6. Search for additional populations to determine the species' full range and abundance.
7. Monitor select known populations to determine whether they are meeting the recovery criteria.
8. Collect viable seeds, using ecologically sound practices, and deposit them in a long-term storage facility.
9. Annually assess the success of recovery efforts for the species.
10. Develop material to inform the public about the status of the species and the recovery plan objectives.

Recovery Costs: Recovery costs cannot be determined at this time.

Recovery Date: Delisting could be initiated as early as 2002 if the above criteria are met.

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PART I

INTRODUCTION

Helianthus eggertii (Eggert's sunflower) is a perennial herb that flowers primarily in August and September. Although Small (1903) originally described the species in 1897, most collections and distribution records have been made since 1990, when extensive searches for the species began (Jones 1991, Kentucky Natural Heritage Database [KNHD] 1999, Tennessee Natural Heritage Database [TNHD] 1999). Eggert's sunflower is typically associated with the barrens ecosystem of the Interior Low Plateau Province. DeSelm (1989) describes the barrens of the Southeastern United States as:

... vegetation resembling tallgrass prairie, but in the central southeast, as in Tennessee and Kentucky, the term may include scrub forest, woodland, and savanna with grass-dominated openings (open barrens or prairie), and low density forest with grass understory.

Historically, drought and fire likely maintained this complex of generally subxeric (somewhat dry) plant communities. (There are, however, more mesic [wetter] sites within the barrens complex.) *Helianthus eggertii* is found in northern Alabama (1 county), central Tennessee (13 counties), and central Kentucky (6 counties), coincident with the distribution of barrens habitat in these States. The U.S. Fish and Wildlife Service (Service) listed this species as threatened on May 22, 1997, under the Endangered Species Act of 1973, as amended (Service 1997).

The primary reason for the rarity of *H. eggertii* is the decline in the barrens ecosystem due to the exclusion of periodic fire and conversion of the habitat for other uses, principally agriculture and development. Other threats to this species include competition from invasive weedy plants, genetic degradation through outcrossing (plant reproduces with a plant from a different strain of the same type of plant) with other sunflowers, and roadside and power line maintenance (herbicide spraying and inappropriately timed mowing).

Description

The following description is summarized from Cronquist (1980) and Jones (1991). *Helianthus eggertii* is a perennial that can form extensive clonal clumps through rhizomatous extensions. The stem is 0.3 to 2 meters (1 to 6 feet) in height with opposite leaves that are sessile (without a stalk), lance-shaped and are either scabrous (rough) or glabrous (smooth) on the upper surface. There are usually few flower heads, and they have long peduncles (stalks). The heads have both yellow ray flowers (outer flowers that appear to be "petals") and disc flowers (those in the crowded center of the head). The bracts (modified leaves), surrounding the flower head, are lance-acuminate (tapering to a point), and the fringes are ciliolate (covered with tiny hairs).

The following combination of characteristics distinguishes *H. eggertii* from other sunflowers: white glaucous (grayish/blue green due to a white powder) stem and underside of the leaves, sessile (petioles <0.5 cm (0.2 inches (in))) leaves that taper at the base, and flower head size (2 to 2.5 centimeters [cm] (0.8 to 1.0 in) across). Also, its vegetation has a distinctive bluish cast.

Other sunflowers that may be confused with *Helianthus eggertii* are *H. strumosus*, which has petiolate (stalked) leaves, and *H. laevigatus*, an Appalachian species that has smaller flower heads. *Helianthus eggertii* often occurs with *H. microcephalus*, which has very small flower heads and petioled leaves, and *H. mollis* and *H. hirsutus*, both species with pubescence (hairs) on the stem and leaves. Some *H. eggertii* occurrences that are sympatric with *H. hirsutus* include plants that display characteristics intermediate between the two species, suggesting the possibility that the two species may hybridize.

Distribution

The distribution of *H. eggertii* is within the Highland Rim and Shawnee Hills Sections of the Interior Low Plateau Province (Quarterman and Powell 1978) with a few outlying occurrences¹ on the Cumberland Plateau. It is usually associated with concentrations of barren community types in Alabama, Kentucky, and Tennessee, although the plant has not been found in some extensive barren habitat in the western portion of this area's Highland Rim Section (see Table 1 for counties of occurrence).

Habitat

The barrens ecosystem is a mosaic of habitats ranging from grassy openings to oak woodlands to mixed mesic forest. During presettlement times, this community likely consisted of low density stands of small- to medium-size trees with a semi-open canopy, and a grass or grass/forb ground cover was nearly continuous. A combination of drought, periodic fire started by lightning and Native Americans, edaphic factors (soil-influenced), and grazing maintained these habitats. Common trees in this ecosystem, with some variability from north to south in the range, include post oak (*Quercus stellata*), black-jack oak (*Quercus marilandica*), southern red oak (*Quercus falcata*), red cedar (*Juniperus virginiana*), mockernut hickory (*Carya alba*), winged elm (*Ulmus alata*), and black gum (*Nyssa sylvatica*). Grasses with prairie affinities often dominate the openings in these community complexes, including big bluestem (*Andropogon gerardii*), little bluestem (*Schizachyrium scoparium*), switch grass (*Panicum virgatum*), and Indian grass (*Sorghastrum nutans*).

¹An occurrence is defined in this document as a geographically discrete grouping of plants. Also, occurrences are equivalent to Element Occurrence Records (EORs) in the States' Natural Heritage Program databases. An occurrence is not necessarily a discrete population, although it could be. Some occurrences on Arnold Engineering Development Center do not meet the exact criteria as EORs and include similar management practices as a criterion for consolidating groups of plants into a single occurrence.

Table 1
***Helianthus Eggertii* (Eggert's Sunflower) Extant Occurrences -**
Alabama (Record #1 only) and Tennessee

Sources: Tennessee Division of Natural Heritage (1999),
The Nature Conservancy (1999), and Jones (1991)

Threats: HM=Habitat Modification, IE=Invasive Exotics, SC=Succession, HB=Herbivory, DS=Disease,
RM=Inappropriate Right-of-way Maintenance (Roadside or Utility Corridor), and ORV=Off-road Vehicles

No. (EOR #)	County	Ownership	Size (# stems)	Habitat	Threats
1	Blount, AL	Public?	Hundreds	Roadside	RM
2 (323)	Cheatham	Private	50	Residential area	Mowing
3 (324)	Cheatham	Private	50	Roadside	RM
5 (325)	Cheatham	Private	300	Roadside, shale barren along creek bank	RM
6 (326)	Cheatham	Private	50	Shale barren along creek bank cleared for power line	Herbicides, clearing
7 (327)	Cheatham	Private	100	Roadside, wet shale outcrop surrounded by barrens	RM
8 (328)	Cheatham	Private	10	Power line	Herbicides, clearing
9 (329)	Cheatham	Private	1,000+	Roadside, wetland, creek bank, shale outcrop, power line	RM, herbicides, clearing
10 (330)	Cheatham	Private	90	Roadside	RM
11 (331)	Cheatham	Private	200+	Roadside and logged hillside	RM
12 (343)	Cheatham	Private	Hundreds	Shale outcrop/barren along stream	
13 (344)	Cheatham	Private	Hundreds	Wooded area along stream	ORV
14 (371)	Cheatham	Private	10	Roadside	RM
15 (374)	Cheatham	State	110	Wooded stream, shale barren	ORV

No. (EOR #)	County	Ownership	Size (# stems)	Habitat	Threats
16 (14)	Coffee	Public	Hundreds	Barren	SC
17 (15)	Coffee	Federal	40	Mature pine stand	
18 (16)	Coffee	Federal	500	Young pine stand	SC
19 (19)	Coffee	Federal	40	Upland grassland	
20 (20)	Coffee	Federal	19	Roadside	SC, HM
21 (37)	Coffee	Federal	400	Mature pine stand	
22 (39)	Coffee	Federal	399	Upland grassland	DS
23 (40)	Coffee	Federal	594	Roadside	HM
24 (41)	Coffee	Federal	3,600	Mature pine stand	
25 (42)	Coffee	Federal	231	Roadside	IE SC, HM
26 (43)	Coffee	Federal	664	Roadside	IE, DS
27 (44)	Coffee	Federal	490	Upland grassland	
28 (46)	Coffee	Federal	161	Roadside	DS, IE, HM
29 (47)	Coffee	Federal	338	Roadside	IE
30 (73)	Coffee	Federal	90	Roadside	IE, SC, HM
31 (80)	Coffee	Federal	668	Roadside	
32 (89)	Coffee	Federal	2,684	Clear-cut	
33 (93)	Coffee	Federal	66	Roadside	IE, SC
34 (96)	Coffee	Federal	124	Roadside	
35 (99)	Coffee	Federal	1,042	Clear-cut	
36 (101)	Coffee	Federal	1,200	Young pine stand	
37 (102)	Coffee	Federal	220	Clear-cut	
38 (110)	Coffee	Federal	500	Upland grassland	IE
39 (112)	Coffee	Federal	70	Roadside	IE, SC, HM
40 (114)	Coffee	Federal	641	Roadside	
41 (116)	Coffee	Federal	144	Roadside	IE, SC
42 (117)	Coffee	Federal	118	Roadside	IE, HM, SC
43 (118)	Coffee	Federal	429	Roadside	

No. (EOR #)	County	Ownership	Size (# stems)	Habitat	Threats
44 (119)	Coffee	Federal	50	Mature pine stand	
45 (120)	Coffee	Federal	92	Roadside	IE, SC, HM
46 (123)	Coffee	Federal	128	Roadside	IE
47 (130)	Coffee	Federal	532	Upland grassland	
48 (139)	Coffee	Federal	731	Upland grassland	HM
49 (140)	Coffee	Federal	115	Roadside	IE, SC, HM
50 (141)	Coffee	Federal	507	Upland grassland	DS
51 (144)	Coffee	Federal	30	Upland grassland	IE, SC
52 (150)	Coffee	Federal	400	Upland grassland	
53 (153)	Coffee	Federal	50	Upland grassland	
54 (155)	Coffee	Federal	239	Hardwood interior	SC, HB
55 (159)	Coffee	Federal	2,000	Clear-cut	
56 (161)	Coffee	Federal	5	Clear-cut	IE, SC
57 (165)	Coffee	Federal	25,200	Clear-cut	
58 (169)	Coffee	Federal	1,306	Roadside	HM, HB
59 (174)	Coffee	Federal	59	Roadside	IE, SC
60 (214)	Coffee	Federal	74	Roadside	IE, HM, SC
61 (216)	Coffee	Federal	34	Roadside	IE, SC, HM
62 (217)	Coffee	Federal	30	Roadside	HM, HB
63 (218)	Coffee	Federal	1,058	Roadside	
64 (219)	Coffee	Federal	21	Roadside	HM, IE
65 (220)	Coffee	Federal	10	Roadside	SC, HM, IE
66 (223)	Coffee	Federal	298	Roadside	IE, HM, SC
67 (227)	Coffee	Federal	287	Roadside	IE, HM
68 (228)	Coffee	Federal	10	Upland grassland	
69 (229)	Coffee	Federal	7	Upland grassland	HM, DS
70 (245)	Coffee	Federal	34	Pine plantation edge	SC, IE, DS
71 (247)	Coffee	Federal	411	Roadside	IE, HM, SC, DS

No. (EOR #)	County	Ownership	Size (# stems)	Habitat	Threats
72 (248)	Coffee	Federal	5	Upland grassland	IE, HM
73 (252)	Coffee	Federal	13	Roadside	SC
74 (255)	Coffee	Federal	266	Roadside	HM, SC
75 (258)	Coffee	Federal	616	Upland grassland	DS, HB
76 (259)	Coffee	Federal	550	Mature pine stand	
77 (263)	Coffee	Federal	242	Upland grassland	HM, DS, HB
78 (268)	Coffee	Federal	100	Mid-aged pine stand	
79 (271)	Coffee	Federal	314	Upland grassland	HM, HB
80 (272)	Coffee	Federal	181	Roadside	SC, HB
81 (298)	Coffee	Federal	67	Roadside	IE
82 (303)	Coffee	Federal	137	Upland grassland	DS, HB
83 (349)	Coffee	Private	200	Roadside - scattered within trees	
84 (382)	Coffee	Federal	Unknown	Upland grassland	
85 (81)	Coffee/Franklin	Federal	287	Roadside	
86 (82)	Coffee/Franklin	Federal	2,680	Mid-aged pine stand	
87 (111)	Coffee/Franklin	Federal	8,321	Upland grassland	
88 (211)	Coffee/Franklin	Federal	33	Roadside	IE, HM, SC
90 (48)	Davidson	Public	Small population	Roadside	HM, trail construction
91 (49)	Davidson	Public	Small population	Roadside	HM, trail construction
92 (50)	Davidson	Public	500	Barren	HM, trail construction
93 (51)	Davidson	Private	Small population	Roadside	RM
94 (52)	Davidson	Private	Small population	Roadside	RM
95 (53)	Davidson	Public	Small population	Barren	HM, trail construction
96 (54)	Davidson	Public	Small population	Barren	HM

No. (EOR #)	County	Ownership	Size (# stems)	Habitat	Threats
97 (314)	Davidson	Public	~100	Power line	RM
98 (315)	Davidson	Public	1,250	Power line, wooded hillside, creek edge	RM, HM
99 (316)	Davidson	Public	116	Wooded hillside	HM
100 (317)	Davidson	Public	200	Wooded hillside	HM
101 (318)	Davidson	Public	350	Wooded hillside	HM
102 (319)	Davidson	Public	2	Wooded hillside	HM
103 (320)	Davidson	Public	2	Wooded, grassy hillside	HM
104 (332)	Davidson	Private	100	Roadside	RM
105 (333)	Davidson	Private	25	Roadside and wooded slope	RM
106 (334)	Davidson	Private	50	Roadside power line	RM
107 (335)	Davidson	Private	10	Roadside fence row	RM
108 (336)	Davidson	Private	200+	Power line	RM
109 (7)	Dickson	Private	Several plots	Roadside and power line	RM
110 (321)	Dickson	Private	5	Roadside near wooded edge	RM
111 (322)	Dickson	Private	200	Roadside near wooded edge in a spring	HM, RM
112 (351)	Dickson	Private	50	Roadside ditch and fence row	RM
113 (352)	Dickson	Private	100	Power line and cleared adjacent areas	RM
114 (354)	Dickson	Public/Private	110	Roadside barren	RM
115 (356)	Dickson	Private	150	Roadside and woodland edge	RM
116 (370)	Dickson	Private	25	Power line, roadside	RM
117 (17)	Franklin	Federal	1,410	Clear-cut	
118 (18)	Franklin	Federal	3,890	Mature pine stand	
119 (26)	Franklin	State	70	Barren	Hybridization and trampling

No. (EOR #)	County	Ownership	Size (# stems)	Habitat	Threats
120 (35)	Franklin	Federal, State	542	Roadside	SC, HM
121 (36)	Franklin	Federal	96	Roadside	IE, SC, HM
122 (55)	Franklin	Federal	7	Roadside	
123 (57)	Franklin	Federal	302	Roadside, edge	
124 (61)	Franklin	Federal	7,540	Mature pine stand	
125 (62)	Franklin	Federal	13,400	Mature pine stand	
126 (63)	Franklin	Federal	110	Hardwood woodland	
127 (66)	Franklin	Federal	375	Mature pine stand	
128 (69)	Franklin	Federal	10	Roadside	
129 (74)	Franklin	Federal	99	Upland grassland	
130 (75)	Franklin	Federal	300	Mid-aged pine stand	
131 (77)	Franklin	Federal	120	Mid-aged pine stand	
132 (79)	Franklin	Federal	131	Roadside	SC, IE
133 (107)	Franklin	Federal	500	Mature pine stand	
134 (108)	Franklin	Federal	200	Upland grassland	
135 (109)	Franklin	Federal	300	Mature pine stand	
136 (163)	Franklin	Federal	700	Clear-cut	
137 (166)	Franklin	Federal	277	Roadside	IE, SC
138 (173)	Franklin	Federal	1,941	Mature pine stand	
139 (175)	Franklin	Federal	11	Roadside	IE, HM, SC
140 (176)	Franklin	Federal	81	Roadside	IE, DS
141 (177)	Franklin	Federal	23	Roadside	IE, SC
142 (179)	Franklin	Federal	16	Hardwood edge	IE, SC
143 (183)	Franklin	Federal	1	Pine plantation interior	SC
144 (185)	Franklin	Federal	894	Mature pine stand	
145 (192)	Franklin	Federal	150	Mature pine stand	
146 (194)	Franklin	Federal	251	Roadside	IE, SC
147 (204)	Franklin	Federal	21	Roadside	SC, IE

No. (EOR #)	County	Ownership	Size (# stems)	Habitat	Threats
148 (210)	Franklin	Federal	6	Roadside	DS, HB, SC, HM
149 (233)	Franklin	Federal	19	Upland grassland	SC, HM
150 (234)	Franklin	Federal	20	Roadside	IE, SC
151 (235)	Franklin	Federal	62	Roadside	SC, IE, HM
152 (236)	Franklin	Federal	123	Roadside	SC
153 (239)	Franklin	Federal	5,000	Upland grassland	
154 (253)	Franklin	Federal	600	Clear-cut	IE, DS, SC
155 (232)	Franklin	Federal	53	Roadside	SC, IE
156 (350)	Franklin	Private	200	Oak-hickory woodland edge	Mowing
157 (380)	Franklin	Federal	Unknown	Clear-cut	
158 (381)	Franklin	Federal	Unknown	Young pine stand	
159 (8)	Lawrence	State	Hundreds	Roadside, woodland edge	RM
160 (12)	Lawrence	State	130		SC
161 (27)	Lawrence	Private	Hundreds	Roadside	RM, SC
162 (28)	Lawrence	Private	Hundreds	Roadside	RM, SC
163 (29)	Lawrence	State	Hundreds	Barren	HM
164 (353)	Lawrence	State	100	Roadside and power line	RM
165 (368)	Lawrence	Private	55	Roadside barren	RM
166 (369)	Lawrence	Private	150	Barren, brushy roadside	RM
167 (376)	Lawrence	State	100	Roadside, woodland edge	RM
168 (1)	Lewis	Private	Hundreds	Roadside	RM
169 (21)	Lewis	Private	150	Gravel roadside	
170 (22)	Lewis	Private	50	Roadside	RM, SC
171 (23)	Lewis	Private	50	Roadside	RM, SC
172 (24)	Lewis	Private	100	Roadside	RM, SC

No. (EOR #)	County	Ownership	Size (# stems)	Habitat	Threats
173 (25)	Lewis	Private	Scattered over 50 yards	Roadside, woodland edge	RM
174 (170)	Lewis	Private (Cons. Trust)	30	Edge of creek and woodland	
175 (337)	Lewis	Private	20	Roadside	HM
176 (338)	Lewis	Private	100	Roadside	HM
177 (339)	Lewis	Private	100+	Limestone seeps	Logging
178 (360)	Lewis	Private	35	Roadside, woodland edge	RM, development
179 (361)	Lewis	Private	50-100	"Reclaimed" barren	Development
180 (362)	Lewis	Private	50	Roadside	RM, development
181 (363)	Lewis	Private	50	Roadside and open wood lot	RM, development
182 (364)	Lewis	Private	200	Roadside, barren	RM, development
183 (365)	Lewis	Private	Few	Edge	
184 (366)	Lewis	Private	80	Roadside	RM, development
185 (373)	Lewis	Federal	10	Power line	RM
186 (378)	Lewis	Private	100+	Barren	Logging
187 (379)	Lewis	Private	20	Dry slope on creek bank	Logging
188 (9)	Marion	Private	30	Roadside	RM, hybridization
189 (10)	Maury	Private	1 large clump		Extirpated?
190 (13)	Maury	Private	10-20 clumps	Roadside	RM, ORV
191 (345)	Robertson	Private	200+	Roadside	RM
192 (346)	Robertson	Public	300+	Power line	RM
193 (347)	Robertson	Private	400+	Roadside, barrens along creek	RM
194 (348)	Robertson	Private	100	Power line and adjacent woodland edge	RM, development
195 (172)	Van Buren	Private	30	Roadside	RM, development

No. (EOR #)	County	Ownership	Size (# stems)	Habitat	Threats
196 (171)	Williamson	Private	Small population	Farm road	
197 (342)	Williamson	Private	25	Logging road	
198 (355)	Williamson	Private	150	Roadside and wooded fence row	RM
199 (357)	Williamson	Private	50	Roadside ditch and edge of driveway	RM, development
200 (358)	Williamson	Private	60	Roadside and fence row	RM
201 (359)	Williamson	Private	600	Roadside fence and ditch; grazed, cleared woodland	RM, development, grazing
202 (367)	Williamson	Public?	Hundreds	Roadside/open barren	RM, development
203 (375)	Williamson	Private	25	Calcareous seep in old logging road	ORV, development

***Helianthus Eggertii* (Eggert's Sunflower) Extant Occurrences - Kentucky**

Source: Kentucky State Nature Preserves Commission

No. (EOR #)	County	Ownership	Size (# stems)	Threats
1 (7)	Barren/Edmonson	Private	145	Roadside barrens, weed competition
2 (8)	Edmonson	Federal	462	Roadside, weed competition
3 (14)	Edmonson	Private	221	Weed and woody shrub competition
4 (27)	Edmonson	Federal	67	Roadside, shading?
5 (12)	Grayson	Conservation group	490	Browsing (deer), shading
6 (28)	Grayson	Private	873	Partially roadside
7 (13)	Hardin	Conservation group	128	Insect damage extensive
8 (29)	Hardin	Private	500	Roadside
9 (30)	Hardin	Private	305	Roadside
10 (31)	Hardin	Private	77	Roadside

No. (EOR #)	County	Ownership	Size (# stems)	Threats
11 (3)	Hart	Private	75	Roadside, shading
12 (4)	Hart	Private	91 (formerly 270)	Roadside, possible hybrids
13 (9)	Hart	Private	358	Weed competition, damage to heads (insects?)
14 (10)	Hart	Federal	145	
15 (11)	Hart	Federal	Hundreds	Roadside
16 (15)	Hart	Private	3 small patches	
17 (16)	Hart	Private	483	Roadside, woody plant SC, hybrids(?)
18 (17)	Hart	Private	56	Roadside
19 (18)	Hart	Private	621	Roadside, woody plant SC
20 (21)	Hart	Private	275	Roadside
21 (32)	Hart	Private	Estimate 50 to 100	Roadside
22 (22)	Hart	Private	224	Roadside
23 (23)	Hart	Private	Hundreds	Insect (?) damage
24 (24)	Hart	Federal	202	Shading
25 (25)	Hart	Federal	223	Roadside, weed competition
26 (19)	Larue	Private	60	Private drive (subject to maintenance)
27 (20)	Larue	Private	725	Roadside, weed competition

Many forbs and other grasses that are typical of the barrens ecosystem are also common in this grassy cover (DeSelm 1989, Jones 1991). Because of differences in hydrology (water properties/levels), the rolling and variable topography (physical features of a region), and other factors, mesic (moist) forests may also be mixed in these community mosaics where *H. eggertii* occurs. At Mammoth Cave National Park, one of several occurrences of Eggert's sunflower is in a moist forest near, if not on, a small alluvial terrace. There also have been recent discoveries of *H. eggertii* in hillside barrens of Davidson County, Tennessee, on steep, rocky slopes.

Eggert's sunflower is typically found at the interface of woodlands and grassy openings within the barrens and, historically, was probably associated with tree stands across

the barrens. These stands were open, with little woody understory, due to periodic fire. When fire is suppressed, succession continues, with an increase in woody understory and other growth that eventually eliminates *H. eggertii*. Although open to semi-open barrens and woodlands appear optimal for *H. eggertii*, it also tolerates considerable disturbance and a range of light conditions and moisture levels. It persists in, and may even invade, roadsides, power line rights-of-way, or fields that have suitable open habitat (see Table 1).

Barrens are inherently vulnerable to development because they have a sparse tree cover that allows for easier land clearing and because they do not have value as timberland. High quality examples of these community types are also disappearing due to lack of fire. As noted, few good examples of these community types remain and most are considered globally rare (KNHD 1999, TNHD 1999).

At Arnold Engineering Development Center (AEDC), a U.S. Air Force Base in Coffee and Franklin Counties, Tennessee, more than half the sites are classified as "edge"--the interface of woodland and field (McKinney 1997). The most vigorous occurrences at AEDC have been found under conditions of regular fire management with semi-mesic conditions (rather than full sun). Some large occurrences were found in pine plantations, probably because of the techniques used to develop plantations (G. Call, AEDC, personal communication, 1999). AEDC planted some pines among the existing hardwood vegetation, and *H. eggertii* is associated with these older trees within the plantations. In other cases, AEDC developed plantations in old agricultural fields, some of which may have been remnant barren openings. Little intensive site development, such as disking, was done; some areas were surface-scraped with a bulldozer. This combination of light disturbance and regular controlled burns allowed the sunflower and associated vegetation to persist.

Other anecdotal evidence supports the idea that fire is beneficial to *H. eggertii*; when fire is excluded, the species disappears or declines (McKinney 1997, Kral 1983, KNHD 1999). A private landowner reported that a population disappeared in an area that did not burn during a wildfire, while extensive colonies have developed and become a common cover in burned woodlands at the same site (R. Seymour, Kentucky State Nature Preserves Commission, personal communication, 1997). At a Kentucky nature preserve, stem counts of a small colony (ca. 100 stems) increased 50 percent over the 2 years following a prescribed fire in November (M. Shea, The Nature Conservancy [TNC], Kentucky Chapter, personal communication, 1997), while another population continued to decline where only canopy thinning was done.

Soils at *H. eggertii* sites, at least for those areas where a soil survey is available, are typically silt loams or chert loams (Jones 1991, Whitaker *et al.* 1972, Arms *et al.* 1979). These soils are commonly acidic and are highly erodible. Sandstone, limestone, siltstone, or even shale can underlie them.

Life History

Helianthus eggertii blooms in August and September, and the seeds are generally mature within a month. Eggert's sunflower produces viable (capable of germinating) seeds (although there may be a minimum viable population size needed to sustain this production), but vegetative reproduction also contributes to plant establishment. Plants produce extensive rhizomes (roots capable of producing new plants) that, optimally, result in the production of dense clusters of stems. AEDC reports colonies covering more than 5,000 square meters (1.24 acres) (G. Call, *in litt.*, 1998). Plants may also be established from seeds within these clumps, so a mix of different individuals can eventually contribute to these extensive patches (Jones 1991). Therefore, the number of genetically different individuals in a population is difficult to estimate.

Most nonflowering colonies are found under substantial forest cover, so it is likely that a yet undetermined light level is critical to induce flowering. Also, colonies in full sun nearly always produce flowers, some notably more prolific than in forested settings (McKinney 1997). We do not yet understand the role of flowers and seed production in the viability of populations nor do we know the optimal natural conditions for seedling establishment. Heiser *et al.* (1969) determined that perennial sunflowers, including *H. eggertii*, are self-incompatible with obligate outcrossing. It follows that when the number of genetically different individuals in a colony is low, seed set will probably also be low, despite colony size. Heiser *et al.* (1969) also noted that, overall, seed germination in perennial sunflowers was low, at most usually 20 percent. This low germination rate combined with a small number of genetically different individuals in a population would likely result in reduced seedling establishment. Seedlings are rarely reported and may not be common.

Herbivory can substantially affect seed production. One unidentified herbivore that commonly affects sunflowers in Kentucky weakens the tissue of the peduncle, causing the flower heads to drop, and can affect most of the heads produced in a clump. A grasshopper has been seen eating a sunflower head, but it is not known whether this is related to the peduncle damage. Aphids have also been seen surrounding, and piercing, the peduncles of many flowers at AEDC, and it was not uncommon to see adjacent flower heads dried up and broken off (S. Rollins, The Nature Conservancy, Tennessee Chapter, *in litt.*). Also, in several populations, larval insects were found to have destroyed nearly all the mature seeds in several flower heads (Jones 1991; personal observation, 1992). AEDC is currently studying the insects associated with Eggert's sunflower and found 67 insect species representing 58 genera in a 1998 survey, most of which were phytophagous (feed on plants) (Lambdin *et al.*, 1999). A rust (*Puccinia* sp.) has also been found to affect this plant, although the severity of impacts has not been quantified (McKinney 1997).

Helianthus eggertii is a hexaploid (having multiple sets of chromosomes) sunflower, and although its distinctiveness as a species has been established by morphological studies (Heiser *et al.* 1969) and biochemical studies (Spring and Schilling 1991), it probably also

outcrosses with other hexaploid sunflowers (Jones 1991). How commonly this occurs and to what degree this can eventually degrade the genetic integrity of the species is unknown. *H. strumosus*, an occasional associate, is a sunflower with a compatible ploidy level. *H. hirsutus* may hybridize when sympatric with *H. eggertii*, as plants with morphological characteristics intermediate between the two are occasionally encountered.

Reasons for Listing

The quality and extent of the barrens ecosystem have dramatically declined since European settlement. This is primarily due to the disruption of natural fire cycles and conversion of habitat for other uses, primarily development and agriculture. Although it is not known how common *H. eggertii* was within the barrens ecosystem in presettlement periods, Eggert's sunflower has no doubt declined as its habitat has diminished. Other threats that could be contributing to its decline include spraying with herbicides, inappropriately timed mowing of roadside and power line rights-of-way, competition from invasive weedy plants, herbivory, and genetic mixing with other perennial sunflowers.

Most of the Kentucky occurrences are of poor quality due to the low number of plants and poor habitat quality. Many occurrences in all three States are associated with roads, usually at the woods edge of the right-of-way, and a few are in power line rights-of-way. Although roadsides appear to offer a significant habitat for this species, the occurrences in these corridors are vulnerable to maintenance activities. Additionally, although the number of known roadside occurrences is partly a result of their visibility, it is not unusual to find that the plants are most common on this edge and are rarely found in interior forests.

Invasive weedy plants threaten many occurrences (KNHD 1999, TNHD 1999) by out-competing *H. eggertii* for space and/or light. Common species mentioned in these accounts are *Lonicera japonica* (Japanese honeysuckle), *Lespedeza* sp., *Daucus carota* (Queen Anne's lace), and *Smilax* spp. (greenbrier).

Conservation Measures

One hundred and nineteen occurrences¹ are known from Federal land, eight from State-owned land (not including occurrences in public road rights-of-way), and other public entities, including Metro Nashville, own 18 occurrences. Private conservation groups own three occurrences and one of these is also dedicated as a natural area under State law (see Table 1). Several of these properties have management plans either in place or under development to improve the ecological quality of the barrens ecosystem. As noted previously, TNC has introduced fire management on their preserves. AEDC has managed the nonrestricted portion of the Base with a contractor-run AEDC Forest Management Program since the early 1950s; Tennessee Wildlife Resources Agency, under a cooperative agreement initiated in 1954, has been responsible solely for fish and wildlife management through coordination with AEDC's Forest Management staff. AEDC has used controlled burning as

a management tool in pine stands for approximately 15 years and began conducting controlled burns for barrens restoration and Eggert's sunflower management in 1997.

Recovery Strategy

Recovery of *Helianthus eggertii* is based on a multifaceted strategy to ensure the continued existence of the species, including: (1) habitat protection and management, (2) maintenance of sufficient species-level genetic diversity to ensure long-term persistence and adaptability while maintaining population level uniqueness, and (3) a comprehensive environmental education effort.

The following recovery objectives involve determining the genetic and demographic (population structure) factors that contribute to the success, and thus viability, of individual populations of Eggert's sunflower and then ensuring that populations have long-term protection. It is then assumed that if there are enough distinct viable populations protected (in this case 20 populations is considered a reasonable number relative to what has been recommended for other listed plants), the species itself is no longer at risk.

Because current estimates of population/occurrence size are based on stem counts and we do not know what proportion of a population is a result of clonal or sexual reproduction, an effective population size (portion of the population reproducing sexually) is not yet determinable. Further, we do not know how often sexual reproduction occurs, the factors necessary for it to occur, or the pollinators involved. We also do not yet know the range of genetic variation between populations. Thus, as more information becomes available, there could be a significant change, either higher or lower, in the number of populations necessary to ensure the long-term survival of the species. Therefore, while many new occurrences have been discovered, the relative importance of individual occurrences/populations to the species' long-term survival has yet to be determined.

It is currently assumed that the relatively widespread distribution of the species is a critical component of the preservation of the genetic diversity of the species and ultimately its recovery. Rangewide genetic analysis will determine the validity of this assumption.

Habitat protection and management are also critical to the recovery of Eggert's sunflower. The barrens of Tennessee, Kentucky, and north Alabama have been under tremendous pressure for decades as farmland and flatland suitable for residential and commercial development. Further, fire suppression has resulted in the loss of many open barrens to woodlands. Because both fire suppression and development pressures will only likely increase, active management and long-term protection of habitat are essential to recover this species. Further, Eggert's sunflower is now as frequently found in roadside and power line rights-of-way as in true barrens, and these habitats cannot be overlooked as potential recovery habitat. This habitat, though essentially manmade, maintains the early successional stage conducive to *H. eggertii* and, if managed properly, can support healthy populations of the species.

Public outreach efforts are an important component of all recovery efforts. Current efforts by TNC, AEDC, and others to educate other agencies and organizations about the importance of barrens habitat will not only aid in the recovery of Eggert's sunflower but also will prevent other species from declining.

PART II

RECOVERY

A. Recovery Objectives

The ultimate goal of this recovery plan is to remove *Helianthus eggertii* from the Federal List of Endangered and Threatened Wildlife and Plants. *H. eggertii* will be considered for delisting when the following recovery objectives have been met:

1. Long-term conservation/protection of 20 geographically distinct, self-sustaining² populations³ must be secured. Protected populations must be distributed throughout the species' historic range⁴. Protection must include a management plan designed to maintain or improve the habitat of *H. eggertii*. This may be accomplished through management agreements or conservation easements on public land or land owned by private conservation groups.
2. These populations must be under a management regime designed to maintain or improve the habitat and each population must be stable or increasing for 5 years. Population monitoring during these 5 years should be done using methods similar to those outlined in the Appendix.

² A self-sustaining population is self-regenerating and maintains sufficient genetic variation to enable it to survive and respond to natural habitat changes. It has yet to be determined how many individual plants are necessary within a population to satisfy this criteria.

³ A population is currently defined as a group of plants that is isolated by geographic discontinuity or a distance of approximately one-half mile. This definition could, and likely will, be changed as more information becomes available on other demographic factors, such as pollinators and genetics. Groups of plants that are more than half a mile apart can be lumped into the same population if they are under similar management techniques and within close enough proximity to reasonably be considered part of the same population.

⁴ Based on the current number and distribution of occurrences, the relative portions would be 1 population in Alabama, 3 populations in Kentucky, and 16 populations in Tennessee.

B. Narrative Outline

1. Determine optimal habitat or range of optimal habitats and develop site-specific management strategies.

1.1 Determine optimal habitat or range of optimal habitat requirements for *Helianthus eggertii*. Environmental factors affect population success. A description of the optimal conditions for the species is needed in evaluating management applications and evaluating sites for protection. Studies should specifically address the following: (1) the role of disturbance (fire, mowing, forest management, etc.) as a natural factor and as a threat; (2) competition; (3) the relationship of moisture in seed germination and establishment and in adult plant growth; and (4) the relationship of canopy cover to population health and reproductive success.

1.2 Determine optimal site-specific management strategies, including fire (where possible), mowing, canopy-thinning, etc. Determine the frequency and intensity of an optimal controlled burn under various site conditions for the improvement of *H. eggertii* habitat and the optimal season for its application. Where fire is not practicable, investigate mowing and other techniques to provide quality habitat. Also, determine which management strategy(ies) maximizes population expansion.

1.3 Develop and implement management plans for sites containing *Helianthus eggertii*. Strategies must identify methods; i.e., controlled burns, mowing, canopy-thinning, etc., that will be used to restore habitat quality and methods for monitoring the effects of the application of these strategies.

2. Develop management plans and conservation agreements for populations of Eggert's sunflower determined to be essential to the recovery of the species and for other populations as well, where there are willing landowners/managers.

2.1 Develop management/conservation agreements with non-Federal entities having land supporting *Helianthus eggertii* and using specific management strategies for habitat maintenance and/or restoration. Agreements should include a timetable for the implementation of recovery and restoration objectives.

2.2 Develop agreements with Federal agencies that manage land having *Helianthus eggertii* and using specific management strategies for habitat maintenance and/or restoration. Agreements should include highway and utility line maintenance agencies, and their non-Federal representatives, with regard to appropriate spraying and mowing schedules. Agreements should include a timetable for the implementation of recovery and restoration objectives.

3. Evaluate the ecological genetics of the species.

- 3.1 Estimate the relative proportion of genetically distinct individuals (clones or genets) in an occurrence/population.**
- 3.2 Determine the total level of genetic diversity.**
- 3.3 Estimate levels of inbreeding within populations.**
- 3.4 Estimate levels of gene flow within and between subpopulations at different spatial scales to determine reasonable delineations for populations.**
- 3.5 Determine whether a lack of intrapopulation genetic diversity affects the viability of individual populations.** Is seed viability reduced in highly clonal occurrences? Is viable seed production important in maintaining genetic stability for this species?
- 3.6 Determine the role of sexual reproduction in maintaining long-term population viability.** Determine whether seedling establishment is critical to long-term population success and under what conditions successful seedling establishment occurs. Questions these studies should address include: Do colonies develop through rhizomatous growth alone or are seedlings established within the colonies? Can the species increase and stabilize through vegetative/clonal growth at sufficient rates to sustain viable populations without seedling establishment? Do environmental conditions influence asexual or sexual reproduction.
- 4. Determine whether introgression with other species is occurring and evaluate introgression as a threat to the species.** Studies should address the following questions: Should introgression with other species be considered a threat or a natural part of the dynamic genetics of this group in the *Helianthus* genus? If hybridization is occurring, is it a result of increased disturbance that allows species to be near each other more often? Should weedy sunflowers that readily hybridize with *H. eggertii* be eliminated from areas where it occurs?
 - 4.1 Identify hybrid individuals and the taxa involved in hybridization.**
 - 4.2 If there is evidence of hybridization, determine levels of introgression.**
- 5. Determine an estimate of the minimum viable population size.** Using genetic parameters obtained from Tasks 3 and 4 and other life history information, determine the minimum viable population size for *H. eggertii*.
- 6. Search for additional populations to determine the species' full range and abundance.**

7. **Monitor (using guidelines comparable to those in the Appendix) select known populations to determine whether they are meeting the recovery criteria.**
8. **Collect viable seeds, using ecologically sound practices, and deposit them in a long-term storage facility.** Develop a table for periodic viability assessment.
9. **Annually assess the success of recovery efforts for the species.** A timely review of new information and an evaluation of ongoing programs is essential to ensure that full recovery occurs as rapidly and efficiently as possible. Monitoring information may reveal new problems or require shifts in the allocation of resources. Population monitoring should be more rigorous and/or more frequent if a population is in decline. Pilot and full-scale management projects should also be reviewed to ensure their continuing effectiveness.
10. **Develop material to inform the public about the status of the species and the recovery plan objectives.** Public support for the conservation of Eggert's sunflower could greatly encourage landowner assistance in conservation efforts. Informational materials should stress pragmatic reasons for conserving the species and should include intellectual, aesthetic, or moral considerations. Background information about the pharmacological, agricultural, or economic properties of the species; its congeners; or other plant family relatives will help address the questions frequently posed by the public.
 - 10.1 **Prepare and distribute news releases and informational brochures.**
Informational materials should be prepared about the status, significance, and recovery of the species. News releases should be distributed both to major newspapers in the species' range and to smaller newspapers near the species' habitat. Interpretive displays and brochures should be developed for use on public land or in public schools.
 - 10.2 **Prepare articles for popular and scientific publications.** Published articles are necessary to inform local citizens and public officials about the need to protect Eggert's sunflower in its native habitat and to encourage their enthusiastic cooperation in conservation efforts. Scientific publications should identify the most pressing needs for further studies and seek the assistance of college and university researchers who have studied this or closely related species.
 - 10.3 **Develop landowner guidelines for the conservation/management of barrens habitat and the protection of *Helianthus eggertii*.** A brochure or booklet on the value of these ecosystems as natural areas and the significance of *H. eggertii* is needed for distribution to landowners interested in managing their land.

C. Literature Cited

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PART III

IMPLEMENTATION SCHEDULE

Priorities in column one of the following Implementation Schedule are assigned as follows:

1. Priority 1 - An action that **must** be taken to prevent extinction or to prevent the species from declining irreversibly in the **foreseeable** future.
2. Priority 2 - An action that must be taken to prevent a significant decline in species population/habitat quality or some other significant negative impact short of extinction.
3. Priority 3 - All other actions necessary to meet the recovery objective.

Key to Acronyms Used in This Implementation Schedule

AEDC - Arnold Engineering Development Center, U.S. Air Force Base, Coffee County, Tennessee
CPC - Center for Plant Conservation
ES - Ecological Services Division, U.S. Fish and Wildlife Service
FWS - U.S. Fish and Wildlife Service
NPS - National Park Service
R4 - Region 4 (Southeast Region), U.S. Fish and Wildlife Service
SCA - State Conservation Agencies
TNC - The Nature Conservancy

HELIANTHUS EGGERTII (EGGERT'S SUNFLOWER) IMPLEMENTATION SCHEDULE

Priority	Task Number	Task Description	Task Duration	Responsible Agency		Cost Estimates (\$000s)			Comments
				FWS	Other	FY1	FY2	FY3	
2	1.1	Determine optimal habitat or range of optimal habitat requirements for <i>Helianthus eggertii</i> .	3 years	R4/ES	SCA, AEDC, NPS, TNC				
2	1.2	Determine optimal site-specific management strategies, including fire (where possible), mowing, canopy-thinning, etc.	5 years	R4/ES	SCA, AEDC, NPS, TNC				
2	1.3	Develop and implement management plans for sites containing <i>Helianthus eggertii</i> .	5 years	R4/ES	SCA, AEDC, NPS				
2	2.1	Develop management/conservation agreements with non-Federal entities having land supporting <i>Helianthus eggertii</i> and using specific management strategies for habitat maintenance and/or restoration.	5 years	R4/ES	SCA				
2	2.2	Develop agreements with Federal agencies that manage land having <i>Helianthus eggertii</i> and using specific management strategies for habitat maintenance and/or restoration.	5 years	R4/ES	SCA, AEDC, NPS				
2	3.1	Estimate the relative proportion of genetically distinct individuals (genets) in an occurrence/population.	3 years	R4/ES	SCA, AEDC				Genetic analyses (Tasks 3.1-5) have been funded by AEDC. Cost details not known to the Service.
2	3.2	Determine the total level of genetic diversity.	3 years	R4/ES	SCA, AEDC				

HELIANTHUS EGGERTII (EGGERT'S SUNFLOWER) IMPLEMENTATION SCHEDULE

Priority	Task Number	Task Description	Task Duration	Responsible Agency		Cost Estimates (\$000s)			Comments
				FWS	Other	FY1	FY2	FY3	
2	3.3	Estimate level of inbreeding within populations.	3 years	R4/ES	SCA, AEDC,				
2	3.4	Estimate levels of gene flow within and between subpopulations at different spatial scales to determine reasonable delineations for populations.	3 years	R4/ES	SCA, AEDC				
2	3.5	Determine whether a lack of intrapopulation genetic diversity affects the viability of individual populations.	3 years	R4/ES	SCA, AEDC				
2	3.6	Determine the role of sexual reproduction in maintaining long-term viability.	3 years	R4/ES	SCA, AEDC				
2	4.1	Identify hybrid individuals and the taxa involved in hybridization.	3 years	R4/ES	SCA, AEDC				
2	4.2	If there is hybridization, determine levels of introgression.	3 years	R4/ES	SCA, AEDC				
2	5	Determine an estimate of the minimum viable population size.	3 years	R4/ES	SCA, AEDC				
3	6	Search for additional populations to determine the species' full range and abundance.	Ongoing	R4/ES	SCA, AEDC, NPS				
3	7	Monitor select known populations to determine whether they are meeting recovery criteria.	Ongoing	R4/ES	NPS, AEDC, SCA				

HELIANTHUS EGGERTII (EGGERT'S SUNFLOWER) IMPLEMENTATION SCHEDULE

Priority	Task Number	Task Description	Task Duration	Responsible Agency		Cost Estimates (\$000s)			Comments
				FWS	Other	FY1	FY2	FY3	
3	8	Collect viable seeds, using ecologically sound practices, and deposit them in a long-term storage facility.	1 year	R4/ES	CPC, SCA				
3	9	Annually assess the success of recovery efforts for the species.	Ongoing	R4/ES	SCA				
3	10.1	Prepare and distribute new releases and informational brochures.	Ongoing	R4/ES	SCA				
3	10.2	Prepare article for popular and scientific publication.	Ongoing	R4/ES	TNC, AEDC, SCA				
3	10.3	Develop landowner guidelines for the conservation/management of barrens habitat and the protection of <i>Helianthus eggertii</i> .	1 year	R4/ES	SCA				

PART IV

LIST OF RECIPIENTS

The following agencies, organizations, and individuals were mailed copies of this recovery plan. This does not imply that they provided comments or endorsed the contents of the plan.

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Mr. Tom Bennett, Commissioner
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County Executive
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County Executive
Williamson County
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County Executive
Marion County
County Courthouse
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Jasper, Tennessee 37347

County Executive
Dickson County
County Courthouse Annex
P.O. Box 220
Charlotte, Tennessee 37036

County Executive
Cheatham County
County Courthouse
100 Public Square, Suite 105
Ashland City, Tennessee 37015

County Executive
Robertson County
108 Courthouse
Springfield, Tennessee 37172

County Executive
Van Buren County
County Courthouse
P.O. Box 217
Spencer, Tennessee 38585

County Executive
Franklin County
County Courthouse
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County Administrator
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APPENDIX

The following four protocols were developed in 1997 by The Nature Conservancy (Southeast Regional Office) and Arnold Engineering Development Center for detecting changes in stem number: (1) Total Census, (2) Index Plot Census, (3) Index Plot Sampling, and (4) Photopoints. Changes in plant distribution are as important as changes in stem density, so each protocol also describes methods for measuring changes in the distribution or spatial extent of the population.

The criteria for assigning a specific protocol to a population are: (1) population size and distribution and (2) habitat type and scheduled management. Localized occurrences with <1,000 stems are typically censused instead of sampled. Index plots are used for larger and/or more widely dispersed occurrences. Occurrences or index plots are sampled if stems are too numerous to efficiently count. These protocols present a range of monitoring approaches to use and modify as legal protection changes, priority occurrences are selected, and management goals are refined. Each protocol begins with a table summarizing the required number of observers, time, and equipment, followed by the methodology with step-by-step instructions.

Monitoring Method Protocols

1. Total Census

A total census of flowering and nonflowering stems will be conducted for small occurrences contained within distinct boundaries and with <~1,000 stems. It is imperative that the boundaries of the population be determined with a general survey before determining whether a total census is feasible. Either map the boundaries with a GPS or otherwise map and measure the maximum dimensions so that future changes in location and distribution can be detected. Also note signs of disturbance and any evidence of invasive nonnatives or the rust (*Puccinia* sp.) that attacks *H. eggertii*. Photopoints should also be taken to document large changes in habitat structure (see Photopoint Protocol).

Number of Observers: 1-2
Time Requirement: Variable, - minutes/population
Equipment:
30 and 50 m tape as needed (1-2 each, if mapping distribution with grid cells)
Steel pins (2 per tape)
Data sheets
Clipboard
Tally counters (2 per observer)
Compass
GPS
Pin flags
Flagging tape
Spray paint

Instructions

- a. Survey the site to locate the boundaries of the population by systematically walking back and forth through the site. Use pin flags or flagging tape to mark the boundaries as needed. If feasible, map the boundary and the centroid of the population with a GPS. Also map frequency grids if employed. If canopy or other conditions do not permit the use of a GPS, measure and map the maximum perpendicular axes of the population or note the distribution of stems in a frequency grid encompassing the population (see Item c below). Note compass direction and length of each dimension and the location of at least one endpoint of each axis (so that dimensions will be measured along the same axes in the future). The latter can be done by marking the endpoints with a rebar or noting the distance and bearing from another point in the landscape (blazed tree, road sign, etc.).
- b. Use hand counters to tally the total number of flowering and nonflowering stems in the population, and measure the maximum stem height. Record data on a data sheet. Note the incidence of rust (*Puccinia* sp.), disturbance, "drooping" flower heads (pedicel cut just below the flower), and the presence of nonnatives.
- c. If the site is being managed for a more open structure, it is particularly desirable to measure changes in the spatial distribution of the population. Mapping the boundaries with a GPS will provide some information on changes in distribution as long as the boundaries are fairly discrete. Alternatively, frequency of *H. eggertii* stems can be noted in cells of a grid encompassing the population. This will be most meaningful for populations in edge habitats along woodlands that are scheduled to be burned and/or thinned.

Circumscribe the population with a macroplot that extends 10-20 m beyond the population boundary into the management unit or stand. The plot may also extend beyond the population boundaries in the other dimension if desired. Note the presence of *H. eggertii* stems in all grid cells within the plot (e.g., 2 x 2, 5 x 5, 3 x 5, etc.) on the data sheet. Square grid cells are preferred in that they measure distribution with equal resolution in both dimensions. Surveying the grids is easily done by extending two measuring tapes from one edge of the plot to define the boundaries of one row of grids and proceeding down each row, noting the presence of stems at appropriate intervals. The tapes are moved along the plot edge to define each row of grid cells.

2. Index Plot Census

Sampling large populations that are distributed over extensive areas poses several problems. A total census is difficult and time-consuming, with repeatability diminishing as the population area increases. Obtaining high precision with sampling may be difficult or impossible, in which case many plots will need to be sampled to statistically detect a biologically significant level of change. In these cases, index plots are an option. Index plots are subjectively placed to ensure that they represent trends for the majority of the population. The observer considers information on plant distribution and variation in density, environmental variability, and areas expected to indicate change. While statistical inferences cannot be made to the entire population, the observer uses biological intuition to relate changes within the plots to trends in the entire population. Provided that plots can be located so that stems are relatively easy to count (i.e., <500-1,000 per plot) and still capture the population of interest, a census is taken of all flowering and nonflowering stems within each plot. It is advisable to choose low-, medium-, and high-density areas for monitoring. Areas of high density in a given year may be at the high end of a random fluctuation and experience subsequent decreases for one or many years (and vice versa for low-density areas) and thus may not represent trends in the rest of the population (Palmer 1993). Photopoints should also be taken of the plots to document large changes in habitat structure (see Photopoint Protocol).

Number of Observers: 2
Time Requirement: Variable: to hours
Equipment:
Metric tapes, 100 m, 50 m, 30 m, as needed
Steel pins (2 per tape)
Metal stakes, 50-60 cm (for permanent baselines/index plot corners)
Rubber mallet/field hammer
Folding metric rules (2 m)
Data sheets
Clipboards
Tally counters (1-2 per observer)
Compass
GPS
Pin flags
Flagging tape
Spray paint

Instructions

- a. Survey the site to locate the boundaries of the population by systematically walking back and forth through the site before locating the index plots. Use pin flags or flagging tape to mark the boundaries as needed. If feasible, map the boundary and the centroid of the population with a GPS. If canopy or other conditions do not permit the use of a GPS, measure and map the maximum perpendicular axes of the population. Note the compass direction and length of each dimension, as well as the location of at least one endpoint of each axis (so that dimensions will be measured along the same axes in the future). The latter can be done by marking the endpoints with a rebar or noting the distance and bearing from another point in the landscape (blazed tree, road sign, etc.).
- b. Establish one to several index plots in low- and high-density areas of the population and/or in areas expected to show change in response to management or perceived threats. If possible, sample 10% of the total population. Plots should be small enough for a census to be easily taken (no more than 1,000 stems) but large enough to reflect changes on a meaningful ecological scale (i.e., perceived changes are likely to be due to changes in habitat rather than random fluctuations in density on a small scale). If changes in distribution are to be measured within the plot (see Item d below), extend the plot beyond the boundary of plants or make it large enough to encompass roughly equal-sized areas with and without stems. If large plots for frequency contain too many stems for a census, either take a census of a representative subset of the plot or sample it (see Sampling Protocol). Mark the plot corners with rebar or steel stakes and map them with a GPS (or note the distance and bearing to another point on the landscape). Also note the bearing and dimensions of the plot on the data sheet.
- c. Use hand-counters to tally the total number of flowering and nonflowering stems in each index plot, and measure the maximum stem height with a meter stick. If necessary to improve accuracy, plots may be gridded off with tapes and flags to facilitate counting. Record data on a data sheet. Also note the incidence of rust (*Puccinia* sp.), disturbance, “drooping” flower heads (pedicel cut just below the flower), and the presence of nonnatives.

- d. If the site is being managed to obtain a more open structure, it is particularly desirable to measure changes in the spatial distribution of the population. This can also be done with index plots by noting the frequency of *H. eggertii* stems in cells of a grid overlaid on the plot. This will be most meaningful for plots in edge habitats along woodlands that are scheduled to be burned and/or thinned.

Extend the boundary of the index plot at least 10-20 m beyond the population boundary into the management unit or stand so that at least half of the plot does not contain sunflower stems. The plot may also extend beyond the population boundaries in the other dimension if desired. Note the presence of *H. eggertii* stems in all grid cells within the plot (e.g., 2 x 2, 5 x 5, 3 x 5, etc.) on the data sheet. Square grid cells are preferred in that they measure distribution with equal resolution in both dimensions. Surveying the grids is easily done by extending two measuring tapes from one edge of the plot to define the boundaries of one row of grids and proceeding down each row, noting the presence of stems at appropriate intervals. The tapes are moved along the plot edge to define each row of grid cells.

3. Index Plot Sampling

Sampling will be used in populations where stems are either too numerous or otherwise difficult to accurately conduct a census to estimate the total number of flowering and nonflowering stems. In some cases the entire population will be sampled. More often, index plots are established to define a new sampling universe, one chosen to reflect important changes in the population at large, and the plots are sampled. Sampling is selecting part of something with the intent of showing the quality or nature of the whole. Sampling is driven by the monitoring objective, which for *H. eggertii* is to detect a 50% change in the total or mean stem density with 90% power and a false-change error rate of 0.1. In populations with clumped distributions, long rectangular plots or belt transects capture the between-clump variability within the sampling unit, thus increasing precision. The optimal size and shape of the sampling units for obtaining high precision are determined in the field with pilot sampling, as was done at all sampled sites in 1997. Whether sampling along a baseline(s) extending throughout the population or in an index plot, sampling units (e.g., belt transects) are randomly placed. Within each unit, the total number of flowering and nonflowering stems are counted.

Number of Observers: 2
Time Requirement: Variable, to
Equipment:
Metric tapes, 100 m, 50 m, 30 m, as needed
Steel pins (2 per tape)
PVC or metal stakes, 50-60 cm (for permanent baselines/transects)
Rubber mallet/field hammer
Folding metric rules (2 m)
Data sheets
Clipboards
Tally counters (1-2 per observer)
Compass
GPS
Pin flags
Flagging tape
Spray paint

Instructions

- a. Survey the site to locate the boundaries of the population by systematically walking back and forth through the site before locating the baseline or index plots. Use pin flags or flagging tape to mark the boundaries as needed. If feasible, map the boundary and the centroid of the population with a GPS. If canopy or other conditions do not permit the use of a GPS, measure and map the maximum perpendicular axes of the population. Note the compass direction and length of each dimension, as well as the location of at least one endpoint of each axis (so that dimensions will be measured along the same axes in the future). The latter can be done by marking the endpoints with a rebar or noting the distance and bearing from another point in the landscape (blazed tree, road sign, etc.).
- b. If sampling the entire population, establish a baseline by running a metric tape through the center or along the edge of the population and marking each end of the baseline with a metal stake. Note the length and bearing of the baseline. Multiple baselines may be used if necessary. If sampling index plots, establish one to several index plots in low- and high-density areas of the population and/or in areas expected to show change in response to management or perceived threats. If possible, sample 10% of the total population. Plots should be large enough to reflect changes on a meaningful ecological scale (i.e., perceived changes are likely to be due to changes in habitat rather than random fluctuations in density on a small scale). If changes in distribution are to be measured within the plot (see Item d below), extend the plot beyond the boundary of plants or make it large enough to encompass roughly equal-sized areas with and without stems. The sampling universe for estimating stem density may be restricted to the portion of the index plots populated with *H. eggertii*. Mark the plot corners with rebar or steel stakes and map them with a GPS (or note the distance and bearing to another point on the landscape). Also note the bearing and dimensions of the plot on the data sheet.
- c. Select random locations for belt transects by evenly dividing the length of the baseline into the number of transects that will be sampled and choosing a random point within each section. The random point is the first long edge of the transect; transects are placed perpendicular to the baseline. If the population is too wide to make sampling transects equal to the population width, divide the population into roughly equal areas or blocks and randomly assign sampling transects to each area.
- d. To sample each belt, run one metric tape out along the first side of the transect. Permanently mark each end of the transect with a metal stake. For belts that are ≥ 2 m wide, the other edge of the belt can be determined by measuring from the first edge with a folding metric rule as the observer searches the belt. For belts > 2 m wide, delineate the other boundary with another metric tape.
- e. Count the number of flowering and nonflowering stems in each belt transect. Record all information on data sheets.
- f. Also note the incidence of rust (*Puccinia* sp.), disturbance, "drooping" flower heads (pedicel cut just below the flower), and the presence of nonnatives within the index plot. Also measure the maximum stem height in each sampling transect with a meter stick. Record all information on data sheets.
- g. Pilot sampling will be required to evaluate whether the anticipated sample size (i.e., number of transects within the index plot) is likely to meet or exceed the monitoring objectives. Collect data for the first ten randomly selected transect locations and then calculate the sample coefficient of variability (CV). Divide the sample standard deviation by the sample mean to compute the sample CV. If the CV is > 0.5 , then collect data for five more randomly located transects in the same plot and combine with the existing data to compute the new sample CV. If the CV now is ≤ 0.5 , then the sample size is probably large enough. If the CV still is > 0.5 , repeat the last step, adding randomly located transects (five at a time), until the CV becomes ≤ 0.5 .

- h. If the site is being managed to obtain a more open structure, it is particularly desirable to measure changes in the spatial distribution of the population. This can be done by noting the frequency of *H. eggertii* stems in cells of a grid overlaid on the population or index plot. This will be most meaningful for populations in edge habitats along woodlands that are scheduled to be burned and/or thinned.
- i. Extend the frequency plot at least 10-20 m beyond the population boundary into the management unit or stand so that at least half of the plot does not contain sunflower stems. The plot may also extend beyond the population boundaries in the other dimension if desired. Note the presence of *H. eggertii* stems in all grid cells within the plot (e.g., 2 x 2, 5 x 5, 3 x 5, etc.) on the data sheet. Square grid cells are preferred in that they measure distribution with equal resolution in both dimensions. Surveying the grids is easily done by extending two measuring tapes from one edge of the plot to define the boundaries of one row of grids and proceeding down each row, noting the presence of stems at appropriate intervals. The tapes are moved along the plot edge to define each row of grid cells.

4. Photopoints

Photopoints can be used to visually document the structure and composition of the vegetation within and surrounding populations and, subsequently, to document the effects of management and disturbance. Used in conjunction with other monitoring methods, photopoints can strengthen and visually illustrate interpretations and conclusions.

Number of Observers: 2
Time Requirement: Variable, 15 - ? minutes/population
Equipment:
50 m tape (1-2, depending upon mapping methods)
Metal stakes, 50-60 cm (2 per baseline)
Rubber mallet
Data sheets
Clipboard
Compass
GPS
Digital camera
Range pole or other metered object for scale

Instructions

- a. Determine the locations from which photographs can effectively detect changes in the habitat structure. For general population monitoring, space photopoints along a central transect or around the exterior of the population. If using index plots or establishing permanent sampling plots, establish photopoints at one or more of the corners. Establish permanent markers at each photopoint location using the metal stakes. Use a GPS to locate each photopoint or triangulate the stakes to other reference markers or witness trees, recording the appropriate information on the data sheet.
- b. Take photopoints, using a range pole for scale, and record the following for each frame: date, frame number, camera height (use a fixed height for all photos), bearing and angle (e.g., 90°), lens, distance from the camera to the range pole, and location of permanent point. Take notes on the weather conditions. Record the name of the photographer.
- c. Archive the photos and the data sheets, preferably in two safe and accessible locations.